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who say that the cubic foot contained a quadrantal of wine; and as little to believe that these two standards were ever truly adjusted to each other.

But had the original standard of the Roman foot been truly adjusted to the quadrantal, and continued invariable from the time of its first establishment, yet a false measure of it might at one time or other have got into common use at Rome, as well as a false measure of the French foot did at Paris; where in the year 1668, the mason's foot was found to exceed the foot of the Chatelet by $\frac{5}{72}$ of a Paris inch (9), which is above $\frac{1}{14}$ of a London inch: and the unaccountable negligence which appears in the Roman coinage, gives sufficient ground to suspect they were not more accurate in their measures.

LXX. *A Description of a metalline Thermometer; by Keane Fitzgerald, Esq; F. R. S. Communicated by the Right Hon. George Earl of Macclesfield, President of the Royal Society.*

Read May 22, 1760. **I**T is universally allowed, that all bodies, whether solid or fluid, are expanded and contracted by heat and cold; and, as far as experiments of this kind have yet reached, it appears, that scarce any two bodies of different natures, or even of the same; are expanded, or contracted equally by the same degrees.

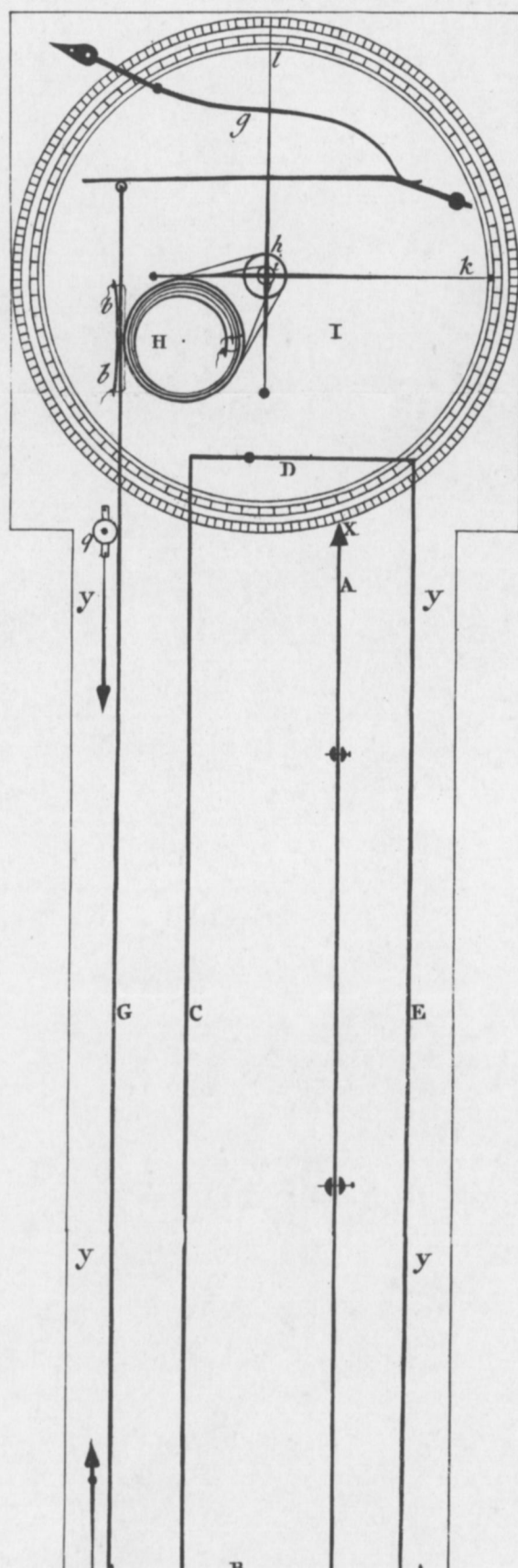
(9) Picard, in the paper *De Mensuris*, quoted above.

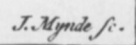
The

The advantages that may be derived from being able, by proper instruments, to ascertain the degrees of natural and artificial heat and cold, with respect to philosophical inquiries; and also to several useful, and common purposes in life; have induced many ingenious persons to apply their thoughts that way; and endeavour to form some certain standard, or gage, by which this may be obtained. The three principal bodies that have been made use of for this purpose; are air, alcohol, and mercury.

Mr. Boyle, the great promoter of experimental philosophy, made a thermometer on the principle of air, which, to a certain degree of heat or cold, answered very minutely. Alcohol, or spirit of wine, has been more generally used; but has been found to lose, in time, much of its expanding quality; and also to be frozen by an intense degree of cold. Mercury, as not deemed subject to these inconveniencies, has therefore been allowed the most proper for the purpose.

The learned Dr. Halley has observed, that mercury expands very sensibly at first, attaining very nearly the same height, some time before the water boils, in which it is placed; that it does on the strongest boiling: whereas spirit of wine expands gradually, as the heat increases; but slower at first, and faster after it is well warm; and, at a certain degree of heat, which wants much of boiling water, being almost tolerable to the touch, it boils vehemently; emitting bubbles, which, coming into the neck of the thermometer, lift the incumbent spirit to the top: from whence he concludes, that the expansion





expansion of fluids graduated by equal parts, is not a sufficient standard of heat and cold.

Mr. Fahrenheit has since improved the mercurial thermometer to a great degree, and brought it to as much perfection as, perhaps, it will bear. He has remarked, that when the barometer shews a greater degree of pressure of the atmosphere; the same liquor will receive eight, or nine degrees of heat, more than when the barometer is at the lowest. But whether this proceeds entirely from the liquor's receiving a greater degree of heat, by the pressure of the atmosphere, may be a matter of some doubt; as it seems, by comparing the mercurial, with other thermometers; to be affected, in some measure, by the pressure of the atmosphere, in all degrees of heat and cold.

The making of metalline thermometers has been hinted at by many; particularly by Mr. Smeaton, in his curious observations on the expansion of metals, who recommends zink, or spelter, as most capable of expansion, and fittest for the purpose. I have endeavoured to make one on this principle, which I take the liberty of laying before this Society, with a description of its construction, and an account of the few observations I have been as yet able to make on it. [*Vide Tab. XVIII.*]

It is composed of four metal bars, which act by a combination of levers, and pullies. The upper end of the bar A, which is 2 feet long, is opposed by a flat piece of metal *x*, screwed fast to a piece of deal board; *y, y, y, y*, and its lower end rests on a small hemisphere, placed on the shorter arm of the lever B, which is fixed to the board *y*.

By

By the expansion of the bar A, the shorter arm of the lever B is pressed down: and as the space described by each of the points of a lever is as the distance from the fulcrum; so the longer arm of the lever B, which is $2\frac{1}{2}$ as long as the other; is raised proportionably; and the second bar C, 2 feet 2 inches long, the lower end of which is placed to the point of the lever B, by a small pin, round which it is moveable; and the upper end, in like manner, to the shorter arm of the second lever D; is raised accordingly; and thereby the longer arm of the lever D, which is $2\frac{3}{4}$ as long as the other, is proportionably pressed down; to which is added the expansion of the bar C, increased, in like manner, by the lever D.

The third bar E, 2 feet 4 inches long, is placed to the point of the longer arm of the lever D, and the shorter arm of the third lever F, which it presses down accordingly; and the longer arm of this lever, which is four times as long as the other, is thereby proportionably raised; to which is also added the expansion of the third bar E, increased by the lever F.

There is an arch-head *d*, fixed to the point of the longer arm of the lever F, to which the fourth bar G, 3 feet long, is fixed by two chains, which raise and lower it, as that arm rises or falls; and, at the distance of 2 feet 6 inches, there is a pulley H, 3 inches diameter. There are two cords fixed to this pulley, surrounding it different ways, one leading upwards, the other downwards, which pass through the bar G, and are fixed to two springs *b*, *b*, which keep them equally tight; and the bar close to
the

the pulley H, which is turned different ways, as the bar G is moved upwards or downwards.

There is a pulley *p* fixed on the other side of the bar G, opposite the arch-head of the lever F, on which the bar rolls; and which, by the help of a slender spring, keeps it close to the arch-head; towards the upper end, there is another pulley *q*, on which it also moves.

The expansion of the bar G, from the place where it is fixed to the arch-head *d*, to the place where it is fixed by the strings to the pulley H, is to be added to the expansion of the other three bars, increased by the several levers.

There are two small pullies *b* and *i*, the pulley *b* one inch diameter, and the pulley *i* a quarter of an inch diameter, whose axis passes through that of the pulley *b*, like the hands of a clock; and on these are placed, in like manner, two indexes *k* and *l*, which move round the dial I, that is 12 inches diameter. These pullies are surrounded by cords, which also surround, and are fastened to springs within the pulley H. The index *l*, which may be called the minute-hand, is moved 4 times round for once the index *k* is moved round; the index *l* ranges at its extreme point 48 times as much as the bar G rises or falls; and the index *k* 12 times.

As the powers of these levers are all reversed, with respect to the pressure by the expansion of the bars; there are two counterballance springs *e* and *f*, placed under the longer arms of the levers B and D, which help to raise the bars easily; and there is another spring *g*, acting on a small roller, placed on the top of the

bar G, which returns all the bars on their contraction.

On the dial-plate I, there are three circles described. The inward circle is divided into 240° , according to Fahrenheit's scale. The middle circle is divided into 360° , which is intended to mark the expansion of different metals. The outward circle is divided into 1080 parts, to which the longer index *l* points, which marks 18 divisions for each degree of the inward circle; and 12 for each degree of the middle circle, pointed to by the index *k*.

The quarter divisions of the dial are marked I, II, III, IIII, to shew, by the index *k*, how often the index *l* has gone round.

There is a screw-hole towards the point, in the index *k*, to fix a small pencil in; which is moved by the index on a circle of wood, or ivory, and marks the highest and lowest degrees it has pointed to, for any time; which saves the continual examination requisite to form observations of this kind; and the mark of the pencil is easily rubbed out, when any new observation is intended.

The first bar A of this instrument may readily be taken out, and replaced; or any other bar of equal length and thickness applied; by which means, the instrument may be used as a pyrometer, to measure the expansion of any bar 2 feet long, with great exactness, to the 73,840th part of an inch *per* foot; and, as a thermometer, it marks the alterations in the temperature of the air, much more sensibly than any other instrument for the purpose; the range of the minute index *l* being 74 inches, by the common degrees of heat and cold of this climate.

If the greatest expansion, from freezing to boiling water, of the metal bars to be made use of in an instrument of this kind, is certainly known; it may be made to mark any minute degree intended. But to answer a calculation of this kind; the levers, and pullies, must be made with the greatest exactness; which I could not prevail on the workman that made mine to be so careful of as I could wish. It is easy, however, to come to a certain knowledge of the expansion, mechanically. I took a thick book, and pressing the leaves between my finger and thumb gently; measured off an inch exactly, with a pair of compasses, from the 1st page, which made 568 pages. I cut off several slips from different leaves, each of which I placed between two bits of watch-spring, which were marked, in order to place them in the same position exactly, on each trial. On examining these with the instrument, I found but few of an exact thickness; but that, on a medium, each leaf raised the minute index 130 divisions. So that the number of pages, each leaf of which is the 284th part of an inch, multiplied by the number of divisions it raises the index; shews, that each division marks the 73,840th part of an inch expansion *per* foot of the bar A, which is 2 feet long.

This bar is made of spelter, which is of so brittle a nature, as makes it difficult to file one of that length without breaking. If it is not well cast, it will be extremely hollow; as was the case of a bar I made use of, which did not expand near as much, nor as uniformly, as another of the same metal, and contracted much more readily; which I could not well account for, until it broke by accident; when

it appeared full of large cavities on the inside, though the outside seemed as fair as any other. Some of these cavities were above an inch long, and the surrounding metal, after filing, not above the thickness of a card. I would therefore recommend the weighing bars of this metal, in order to observe the difference of expansion.

The other bars of this instrument, as the founder informs me, are made of 18 parts spelter, and 2 of copper. I should imagine, that there is a greater proportion of copper than he owns, from the appearance of the metal, and the disproportion in its expansion, to what I suppose 2 parts in 20 might occasion.

Since this instrument has been made, I found, on looking over the 10th volume of Martin's Abridgment of the Philosophical Transactions; that Dr. Mortimer had, in 1735, given the Royal Society a description and drawing of an instrument he invented for the purpose; and that Mr. Johnson had also given a drawing of another, invented by Mr. Fotheringham. Although these are of a very different construction, yet, as they were formed on the same principles, I ought, in justice to these gentlemen, to mention them.

I have made what observations I could on this instrument, since the short time it is made; by comparing it with a Fahrenheit's, and a spirit thermometer; and find, that it keeps at a medium between both; not rising at first so quick as the mercury, and somewhat quicker than the spirit. On placing them together in the sun, when its heat became intense, it rose at last faster than the mercury, and not so fast

as

as the spirit ; and continued to rise for some time after the others became stationary.

I electrified the bars of the instrument, to see if the electrical fire could produce any degree of heat sufficient to expand them ; which, on the first trial, it seemed to do, by the minute index rising 6 divisions in a short time. But as I had some reason to imagine ; that this appearance proceeded rather from an increase of heat, occasioned by two gentlemen being in the room with me, when I made the experiment ; I repeated it alone the next day, leaving the door open at the time, and could not perceive the minute index to rise above one division ; which I attribute rather to the warmth that my being in the room had occasioned.

I tried the expansion of a few metal bars, from artificial freezing, with pounded ice, and water that it dissolved into ; upon which was poured half an ounce of spirit of tartar, in which Fahrenheit's thermometer descended to within one degree only of the freezing point : to boiling water, in which it rose to 211° , though the water did but scarce boil, for want of a sufficient number of lamps. The barometer stood at 30 inches, and the natural heat of the weather at 60° of Fahrenheit.

	Divisions.
* A bar of spelter 2 feet long, marked by the minute index — — — — —	} 157 ^o
Spelter 18 parts, and copper 2 parts, accord- ing to the founder's account — — —	
Brass — — — — —	} 115 ^o
	} 112 ^o

* This was the bar, found, on breaking, to be hollow.

									Divisions.
Iron	—	—	—	—	—	—	—	—	785
Steel	—	—	—	—	—	—	—	—	695

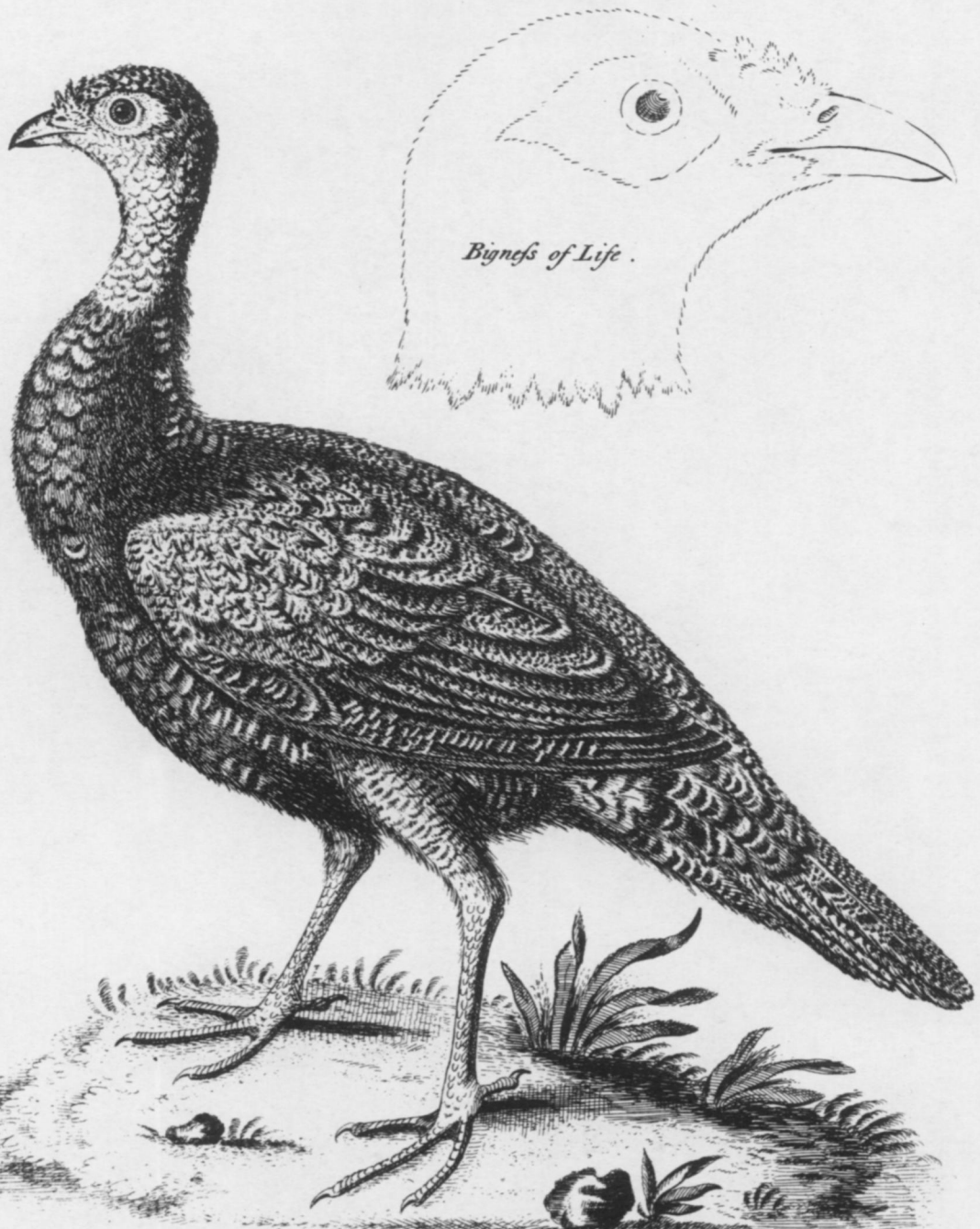
Note. Each division marks the 73,840th part of an inch expansion *per* foot.

I find that these come somewhat near Mr. Smeaton's table. They are far from being as complete as I wish; but hope to be able to give a more accurate account hereafter; as it certainly requires the natural cold to be added to the artificial, in order to get at the last degree of the contraction of metals, which can be come at in this climate.

If an instrument of this kind should be deemed worthy the attention of the curious, there is no doubt, but it may be carried to a much greater degree of perfection than this, which is but a rude beginning. The friction is little or none, as the spring at the top of the fourth bar, keeps the several levers and bars in the same position on their axes, whether rising or falling. It may be made much more easily, and at a less expence, by making use of counterballance weights, instead of springs; and by a cord passing over a pulley placed on the top of the fourth bar, with a weight fixed to it, which returns the bars, on their contraction.

I have one making in this manner. The first bar of which is 3 feet long, and by a slider, which is fixed by a screw, it will measure the expansion of any bar, within that length. The powers of the levers are also greater; and the minute hand goes 12 times round, for once the other goes round; by which it marks the 300,000 part of an inch expansion *per* foot, and ranges 216 inches, by the common degrees of heat and cold in this climate.

Mercury



A Bird supposed to be bred between a Turkey and a Pheasant.

J. Mynde sc.

Mercury cannot be useful in trying any degrees of heat above what makes it boil : and it appears by Dr. Hinfell's account of the experiments lately made at Petersbourg, that it may be frozen by extreme cold ; which makes it unfit for ascertaining the extreme degrees of either.

An instrument of this kind might be made by the help of a tin casing, to come between the bars and the wood, to receive a bar of iron or steel, heated to any degree within that of its melting ; without any detriment to it. And any kind of metal bar will certainly bear the most extreme degree of cold, and probably contract proportionably. I should imagine it might also be made very useful in trying minutely the expansion of different kinds of metals, fit for making compound pendulums ; and the exactness of the pendulum, when made, might likewise be tried, by artificial freezing, or in hard frost, and by boiling it in water.

LXXI. *An Account of a Bird supposed to be bred between a Turkey and Pheasant ; by Mr. George Edwards, F. R. S.*

To the Rev. Dr. Birch, Secretary to the Royal Society.

S I R, •

Read May 22,
1760.

HAVING in my hands a bird, that, I believe, may be a curious and entertaining subject to the Royal Society, I presume, by your favour, to lay it before them [*Vide Tab. XIX.*], with its description, and what other account of it I could